SCIGN science report high resolution mapping, and GPS fault slip sensors

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USGS science for a changing world

SCIGN Southern California Integrated GPS Network

Los Angeles Basin Geological Society

Long Beach, California
September 26, 2002

SCIGN

SOUTHERN CALIFORNIA INTEGRATED GPS NETWORK

The SCIGN array uses GPS to measure the buildup and release of strain on the fault system in southern California

Operational Groups:

USGS science for a changing world

SOPAC

JPL

Major Funding (total of $18 M)

W. M. Keck Foundation

NASA

NSF

USGS science for a changing world

SCEC

SCIGN is an integral part of SCEC


SCIGN
SOUTHERN CALIFORNIA
INTEGRATED GPS NETWORK
Pacific Ocean
UNITED STATES
MEXICO
NEVADA
ARIZONA
SONORA
BAJA CALIFORNIA
Gulf of California
Los Angeles
San Diego
Phoenix
Tijuana
Ensenada
Santa Catalina Island
Death Valley N.P.
Kofa N.W.R.
Tohono O'odham I.R.
Hualapai I.R.

SCIGN
SOUTHERN CALIFORNIA INTEGRATED GPS NETWORK

Status and Plans

- **SCIGN is now almost entirely built (a few remaining things to finish). There's always room for improvement, but we're just about out of W. M. Keck Foundation money (we are under-funded through our current sources of support to continue basic operations in future years).**

- **Impressive list of accomplishments as of April 2002 is on the SCIGN web site. Analysis Committee has re-run '96-'02 series - they agree very well (<1 ppb). Velocities estimated robustly to within 0.5 mm/yr for many stations already (after ~3 yrs.), but groundwater effects confirmed to be a major effect on some stations. Reports due to W. M. Keck Foundation and SCEC BoD. Operations plan update is needed - the EC has agreed to request approx. $1.5M/yr. The SCIGN CB has approved, but we need to raise that money.**

- **We plan to go in with the PBO community on a major, collective proposal (but hard matching funds from SCIGN are not required by NSF, and by the time they'd be needed we'll have run out). The proposal is due in early December - Will Prescott is in charge and has asked for input from SCIGN - we need to provide this. Groups will continue to raise funds, also.**

- **Many who had major roles in SCIGN are now very active in the UNAVCO, Inc. and PBO groups that are carrying forward the PBO initiative. Through this input, lessons learned in creating SCIGN ought to be taken into account during construction of the PBO.**

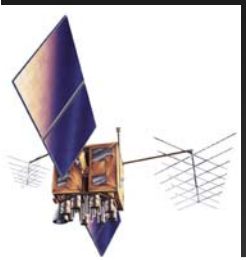
SCIGN
SOUTHERN CALIFORNIA INTEGRATED GPS NETWORK

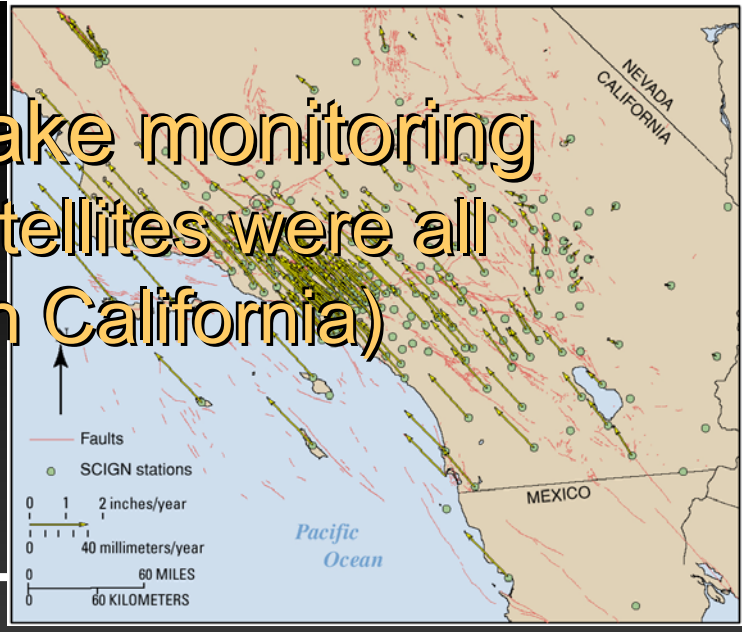
Science Review

- List of publications - updates on the main project web page at http://www.scign.org/
- 45 papers from 1996 through April 2002 (includes several on Hector Mine co-seismic) - many important contributions that would have been impossible without SCIGN.
- BSSA Hector Mine special issue (May, 2002) contains *16 papers* (out of a total of 36) that made direct or indirect use of SCIGN data. Nearly all 36 then also cited these 16.
- Fall AGU 2002 abstracts contain reports on several new projects using SCIGN data in innovative ways, as well as reports of the new results from the ongoing and coordinated SCIGN Analysis Committee effort, chaired by Nancy King. The use of continuous GPS data for various geophysical and other uses is increasing worldwide, and SCIGN has provided data used in a far wider range of studies than was ever imagined (e.g., *Varner and Cannon,* 2002). The open data policy has been a key to success.
- SCIGN has become an integral part of what we - the broader SCEC community - all do here in southern California. These results influence peoples' thinking well outside of our regional scope, just as we all learn greatly from studies of other regions. Others see the value inherent in having a state-of-the-art array like SCIGN available (hence the PBO part of the EarthScope initiative). New data products will make SCIGN data more easily accessible to a larger and broader base of earthquake and other earth scientists.

GPS is now vital to earthquake monitoring

(array technology and GPS satellites were all developed here in Southern California)





Measures buildup of strain on faults due to accumulating tectonic motion

Used to detect damage to large engineered structures such as dams, and effects of ground tilt and subsidence on water systems

Can be used in real-time to detect fault slip at surface, for early warning system

Earthquake scientists and emergency responders need high-rate GPS data in real-time

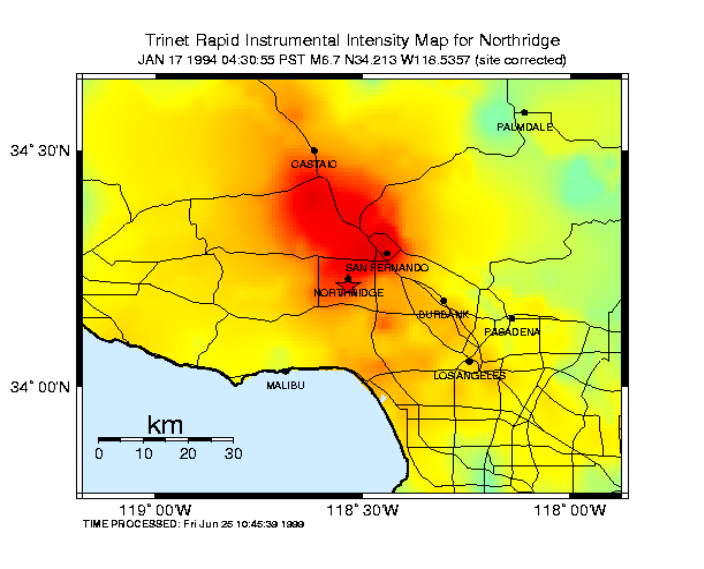
- Earthquake response
  - *to rapidly assess source* (finite fault model feeds back into improved shaking maps)
- Damage estimation
  - *to rapidly assess losses* (ShakeMap and HAZUS, e.g., for use by FEMA and OES)
- Infrastructure for positioning
  - to support spatial and temporal aspects of *fundamental data collection and mapping* (e.g., surface rupture mapping - ALSM)

- **Earthquake response**
  - *rapidly assess the earthquake source*

Hector Mine (M_w7.1)

Damage estimation

- *rapidly assess damage, casualties, and losses*

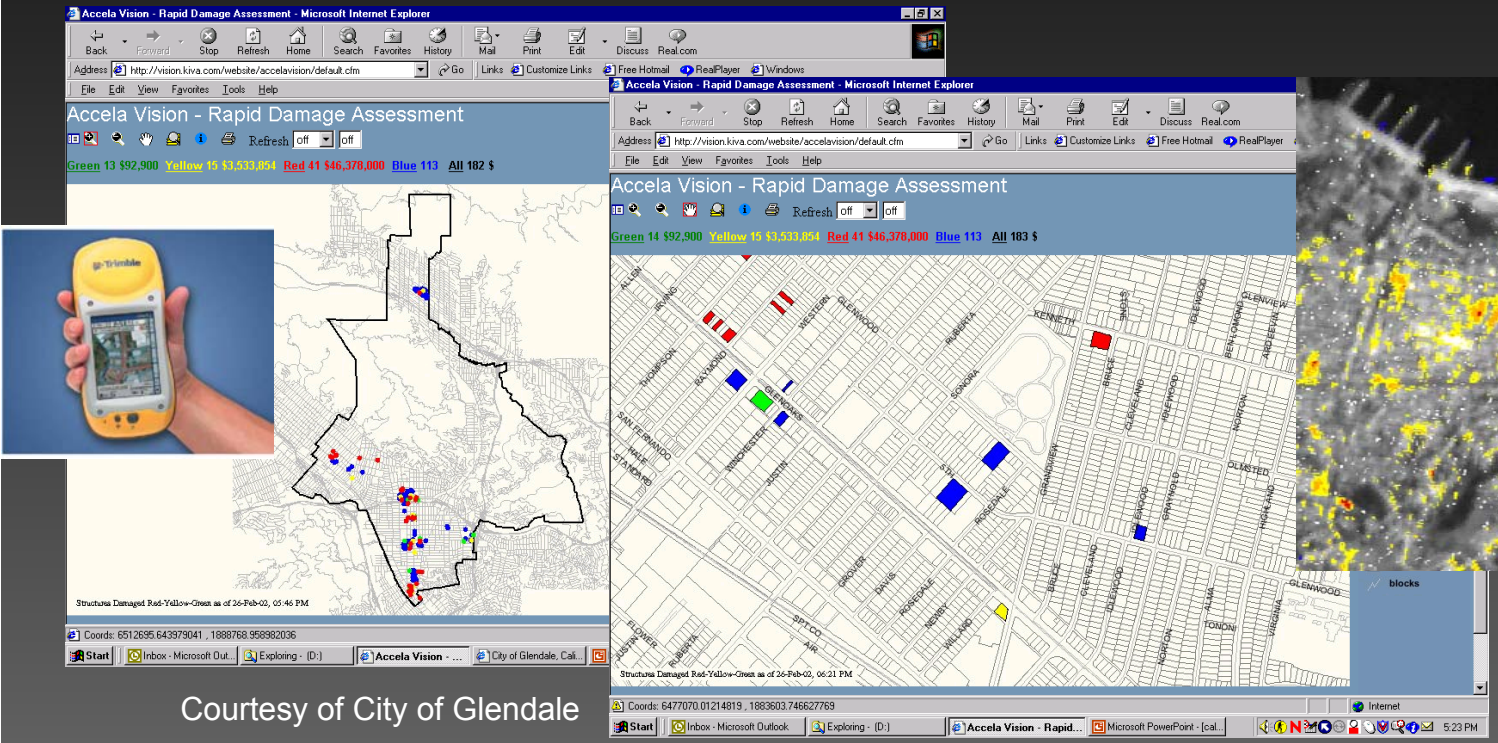


ShakeMap/HAZUS

Pacoima Dam GPS structural health monitoring system
(with LA County since Sept. 1995)

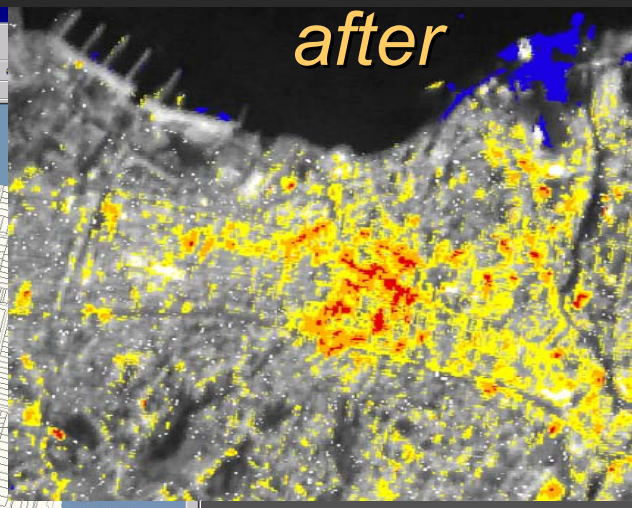
Infrastructure for positioning

- *supports data collection and mapping during disaster recovery efforts*



Courtesy of City of Glendale

imagery before & after



Courtesy of Ron Eguchi

ATC-20 building safety inspections (red, yellow and green tagging)

What we cannot do…

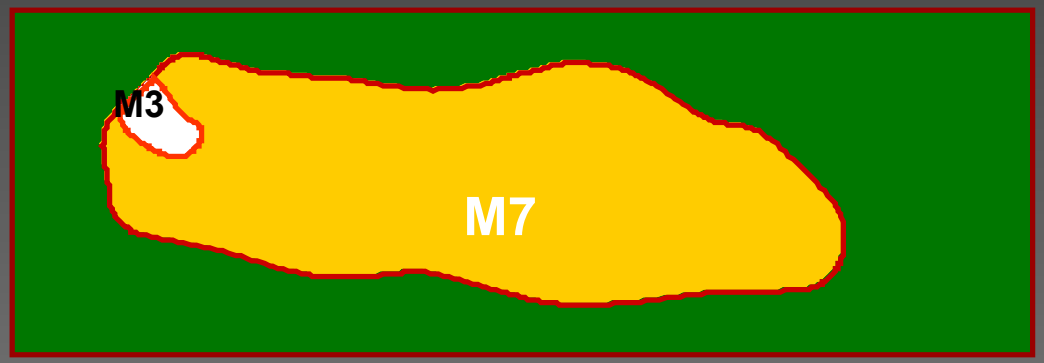
because the physical process is too chaotic

weather – *turbulence*

earthquakes - *friction*

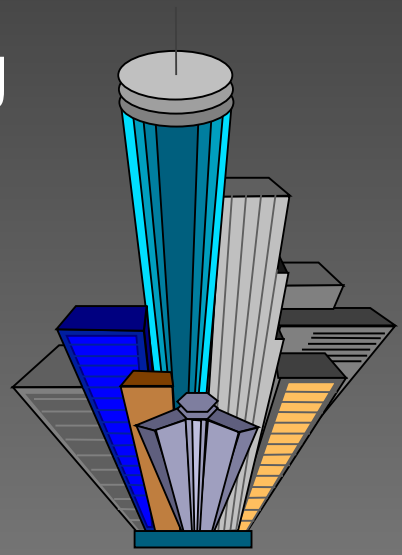
- Recognize a precursor for a particular event
- Differentiate between the beginning of a M3 and a M7

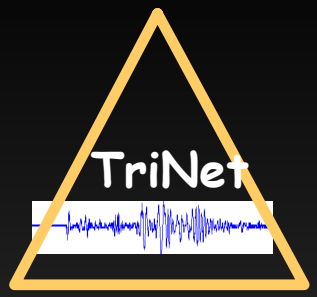
GPS 'slip sensor' can help with this!



Living with earthquakes *without* prediction

- Build to withstand earthquakes
  Earthquakes don't kill people—buildings do
- Evaluate earthquake rates
  "Climate" forecast, not "weather" prediction
- State-of-the-Art Earthquake Monitoring
  Improve earthquake response
  Earthquake early warning

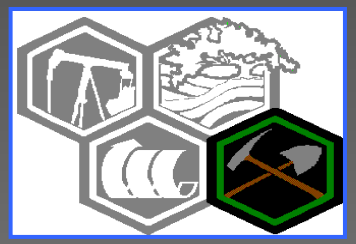




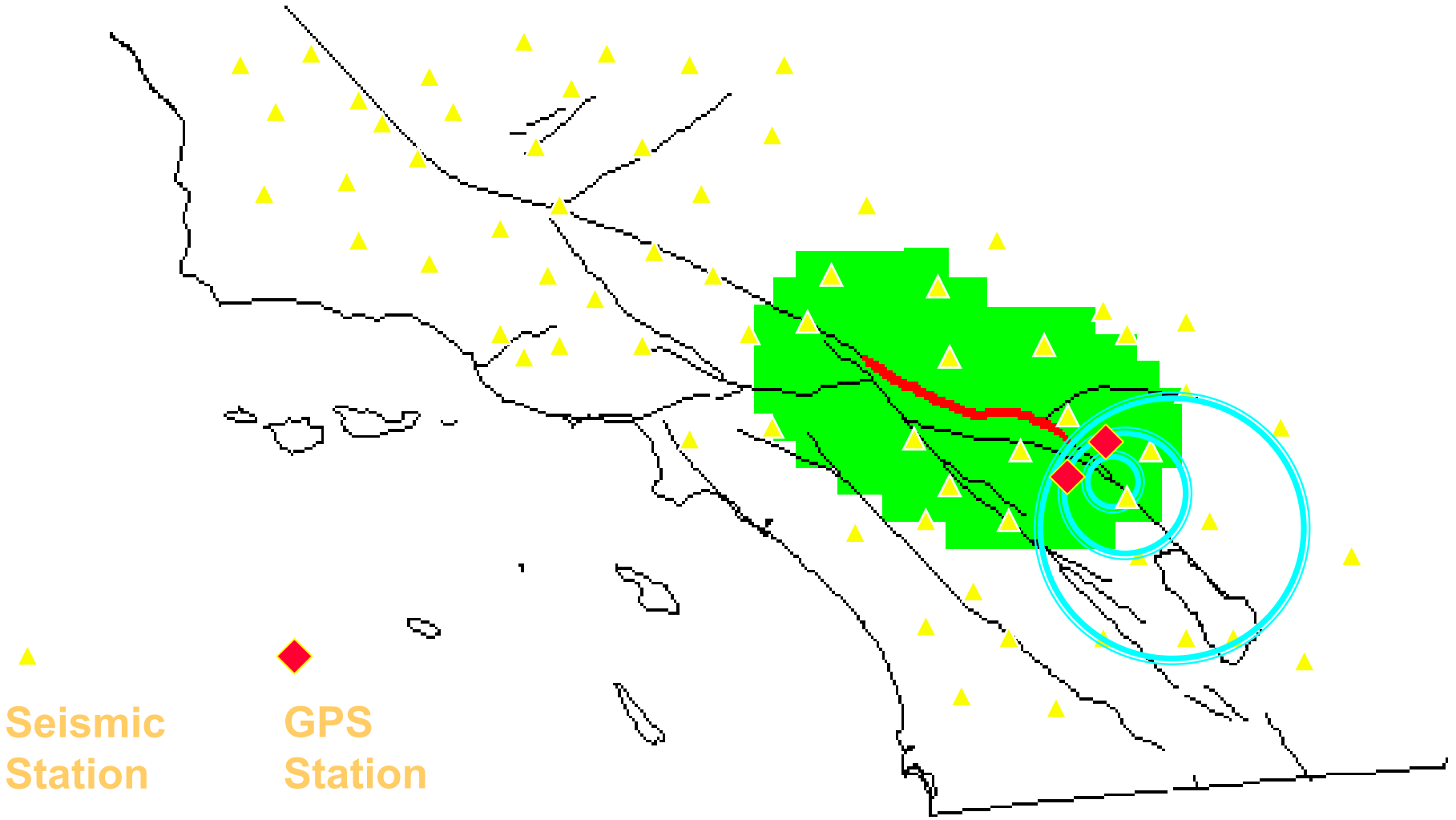
TriNet

A network of ground motion sensors

A cooperative project between:

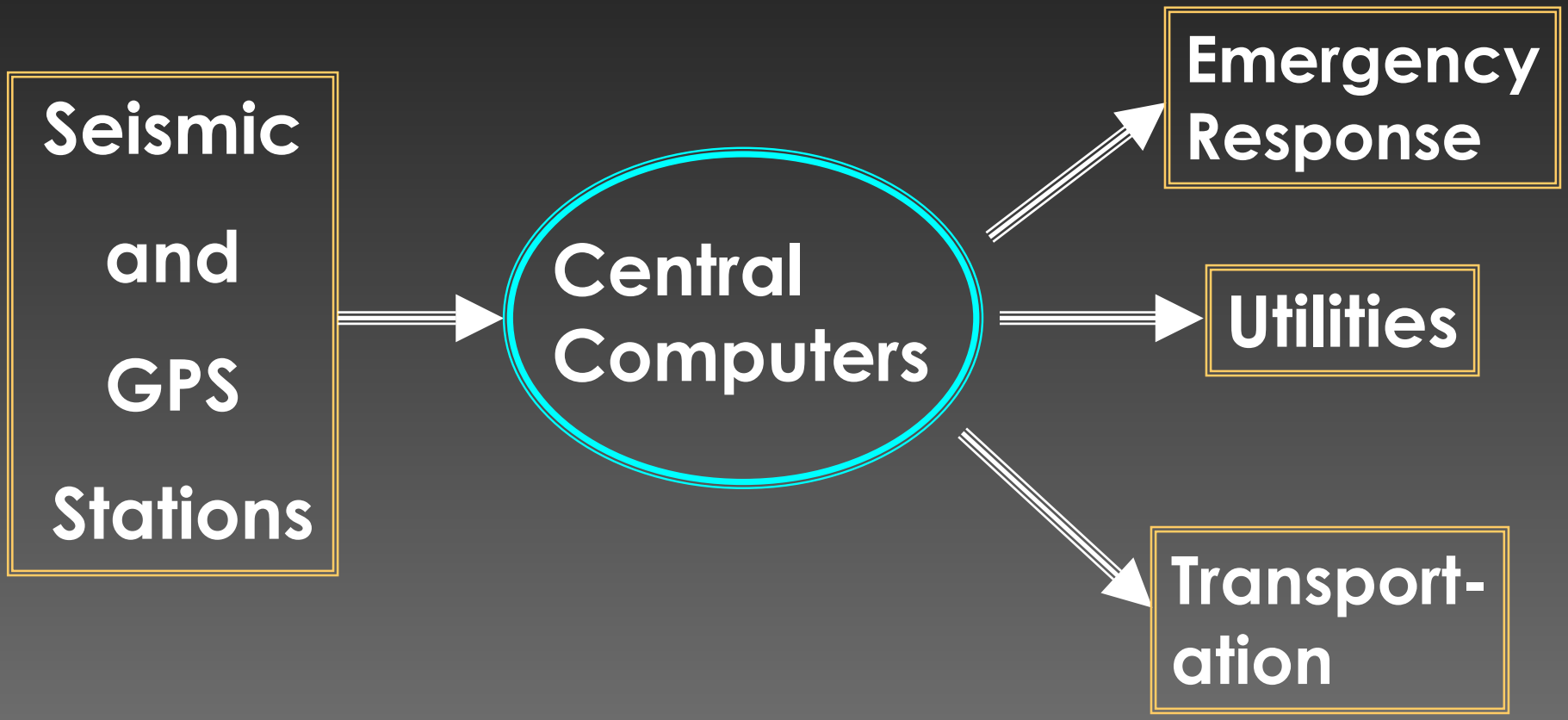


Early Warning



Early Warning

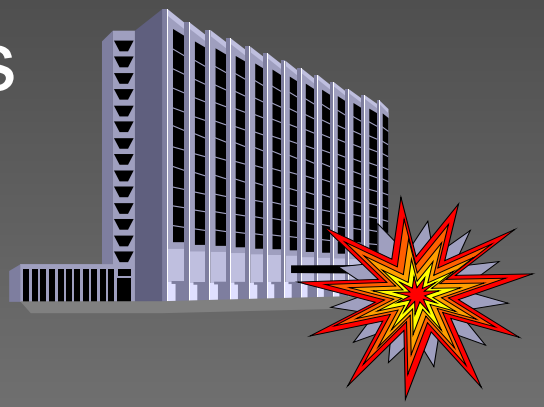
The speed of light >> the speed of sound

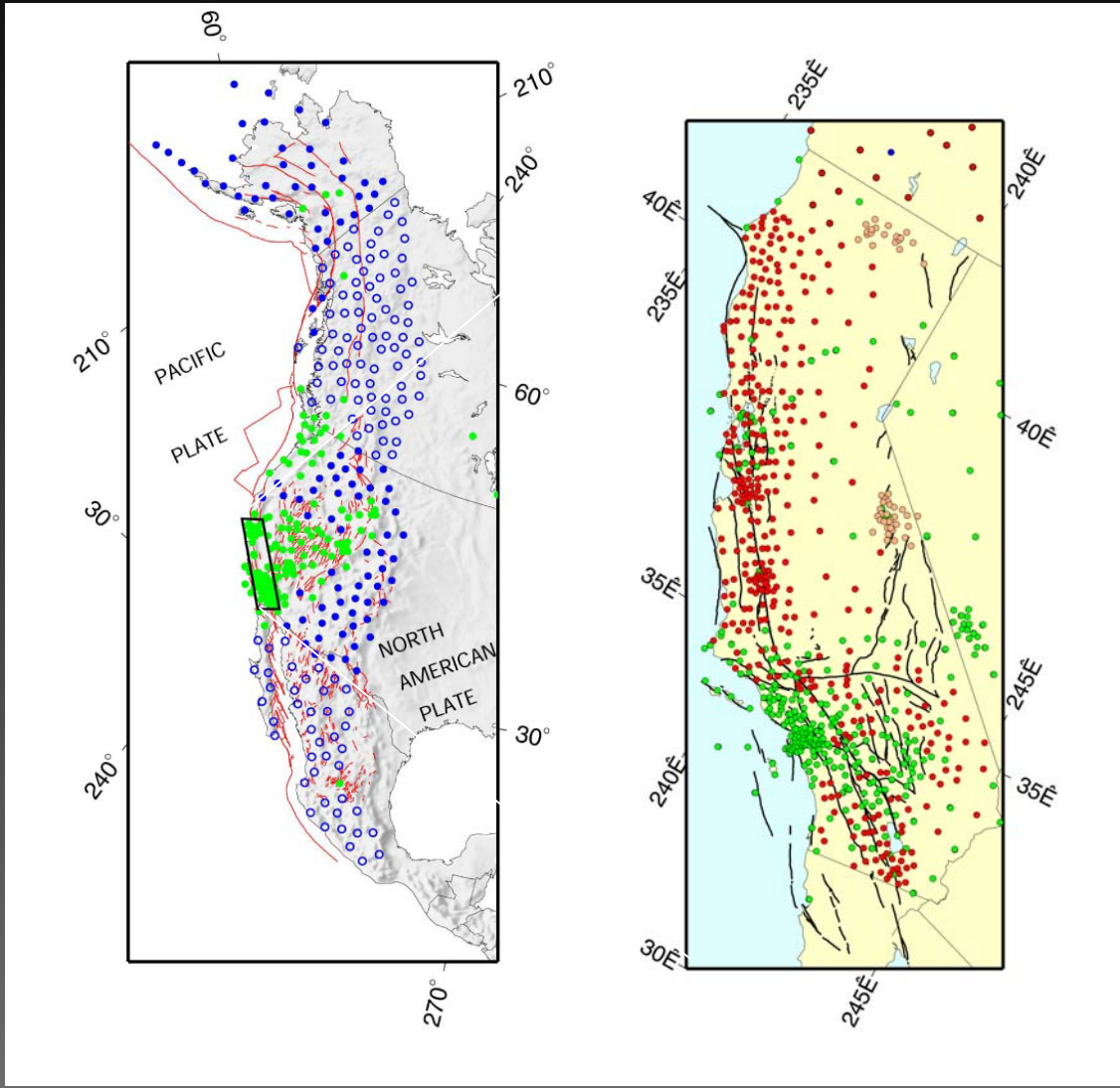


Mitigative Actions

Is 30 seconds of warning enough?

- Stop trains
- Stop nuclear reactions
- Stop computers
- Secure hazardous materials
- Stop elevators





The Plate Boundary Observatory

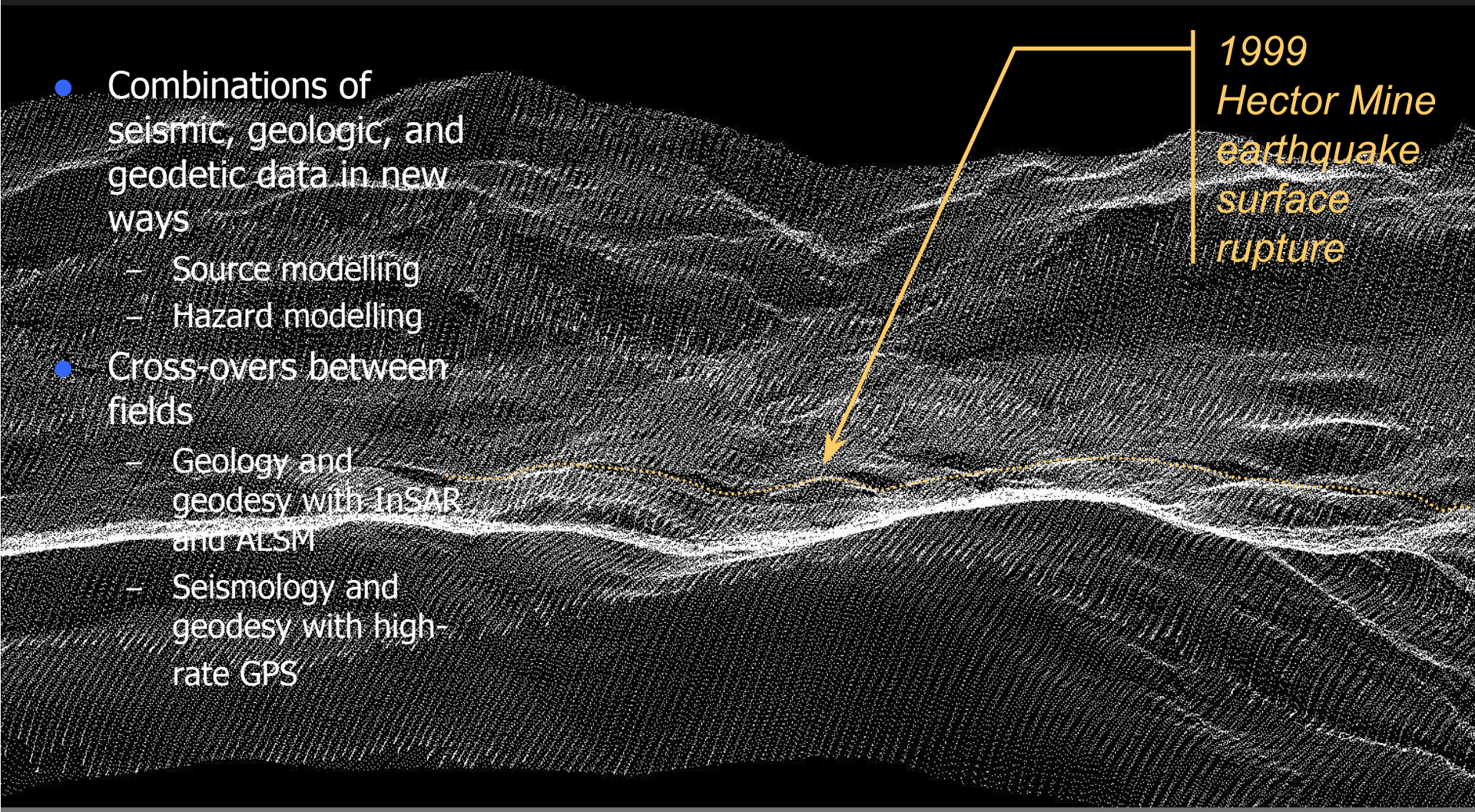
- SCIGN is a prototype deployment for PBO
- PBO will extend the GPS & strain arrays throughout the Western U. S. A. and Alaska
- With Canada and Mexico, we hope to cover the North American – Pacific plate boundary

Surface Rupture

- Mapped by Thomas Dibblee, USGS (he was looking for minerals to make rocket fuel for ICBM's at the time)
- Lavic Lake fault in recognition of breaks through dry lake bed
- Up to 5.7 meters of right-lateral motion
- 45 km overall length of surface rupture
- Only ruptured once previously through 50,000 year-old soils
- Old fault looked harmless, but produced a big earthquake

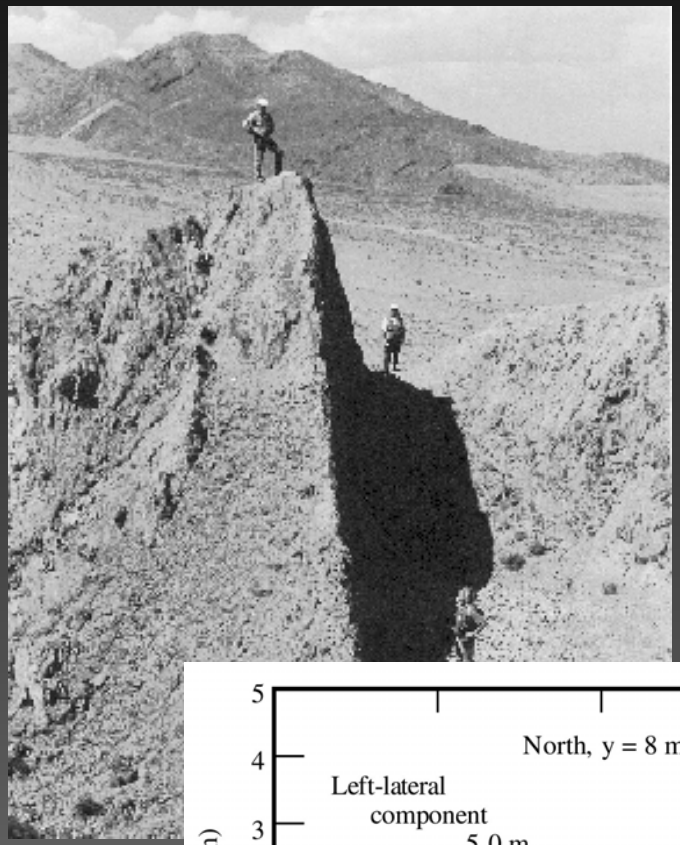
New methods to explore, new synergies between data types (e.g., GPS & ALSM)

- Combinations of seismic, geologic, and geodetic data in new ways
  - Source modelling
  - Hazard modelling
- Cross-overs between fields
  - Geology and geodesy with InSAR and ALSM
  - Seismology and geodesy with high-rate GPS

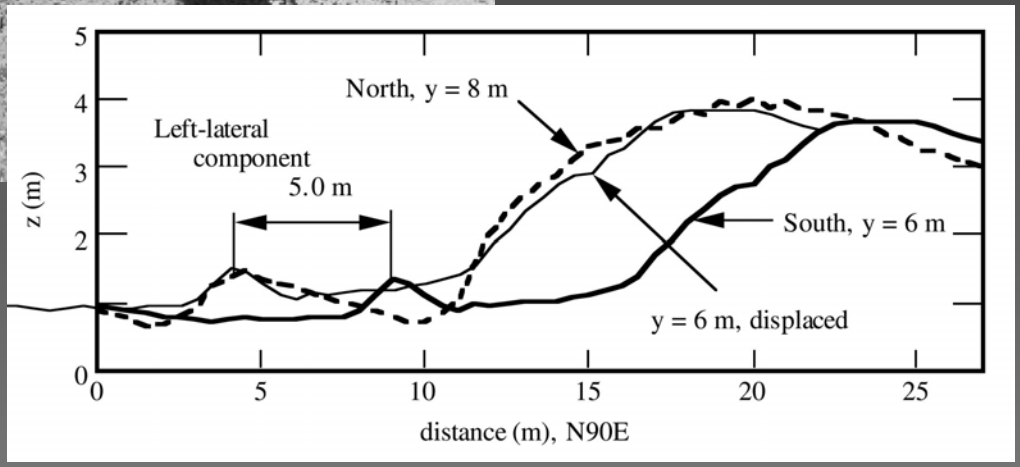


New methods and data integration

- Precise topographic mapping of surface ruptures and active fault scarps
  - slip models for prehistoric events
  - rapid assessment of surface slip and damage patterns after large events
  - Requires precise integration of GPS & INS for flight navigation



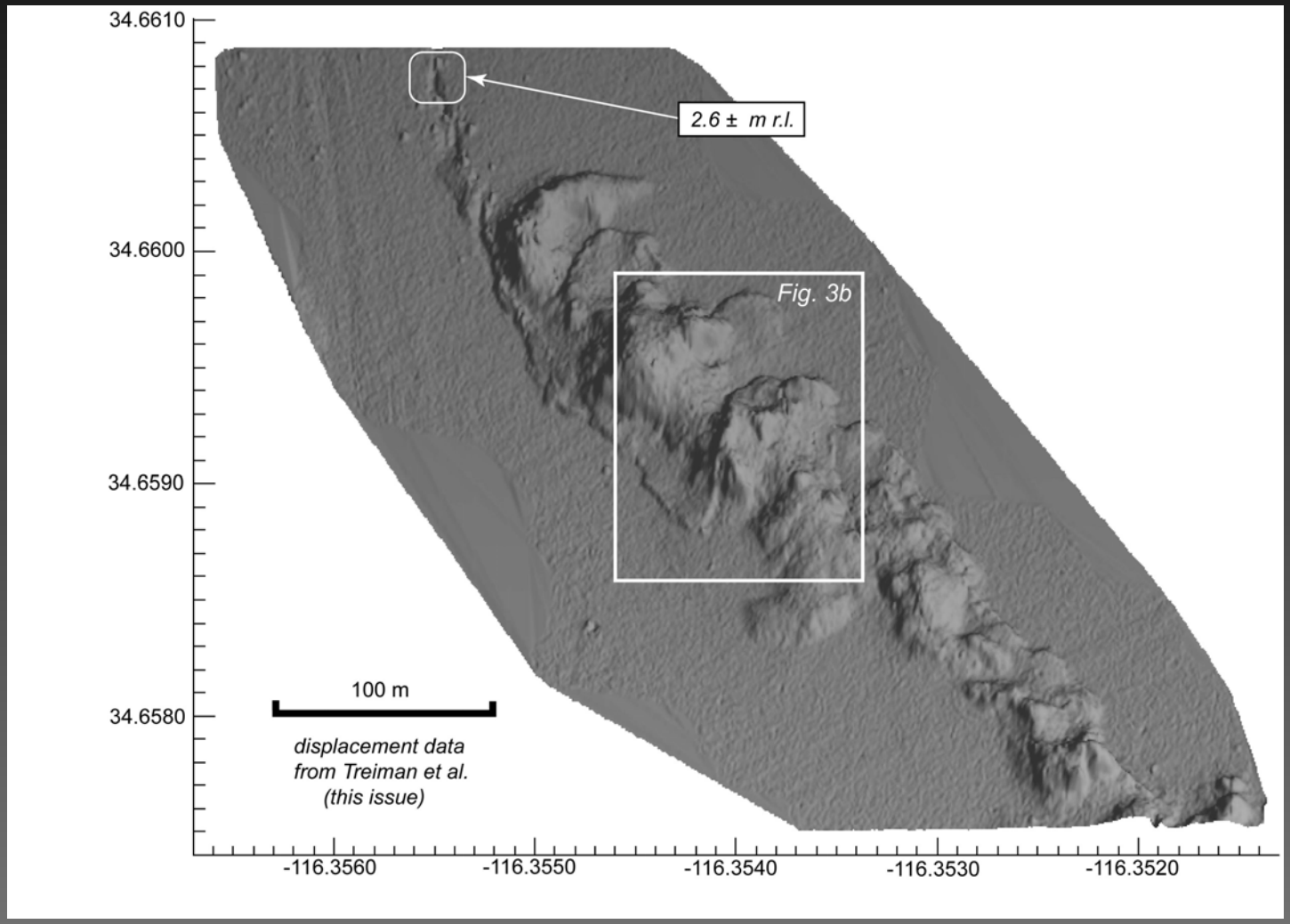
1957 Gobi-Altai earthquake surface rupture



Southwest Corner of Lavic Lake

dry lake bed for calibrations

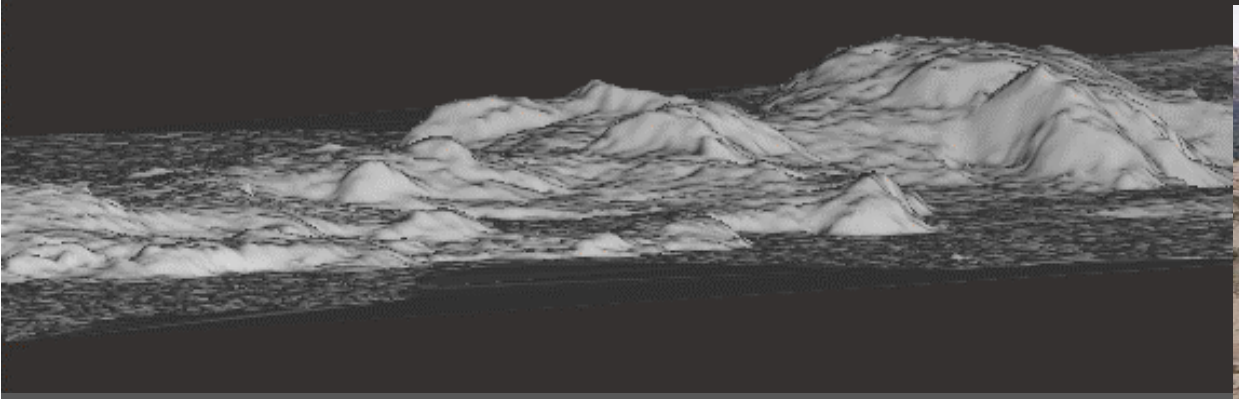
Lavic Lake – compressional step



New methods and data integration

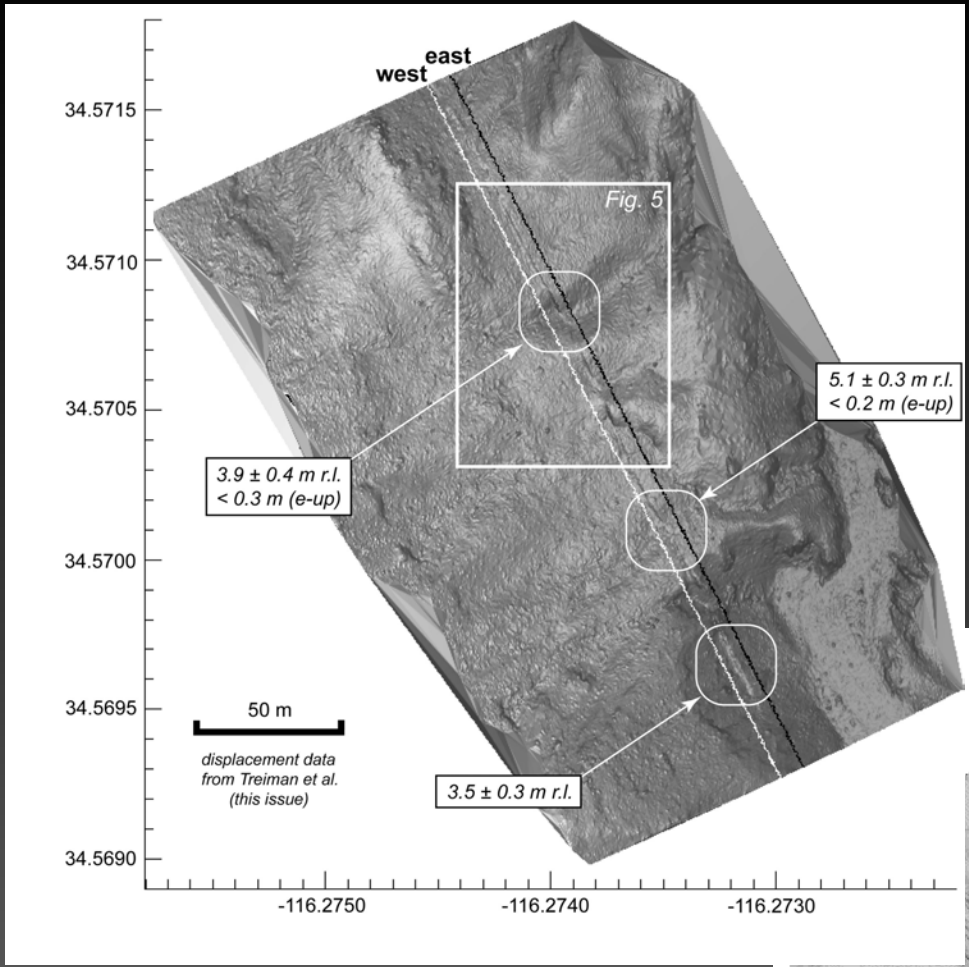
- precise topographic mapping of surface ruptures and active fault scarps

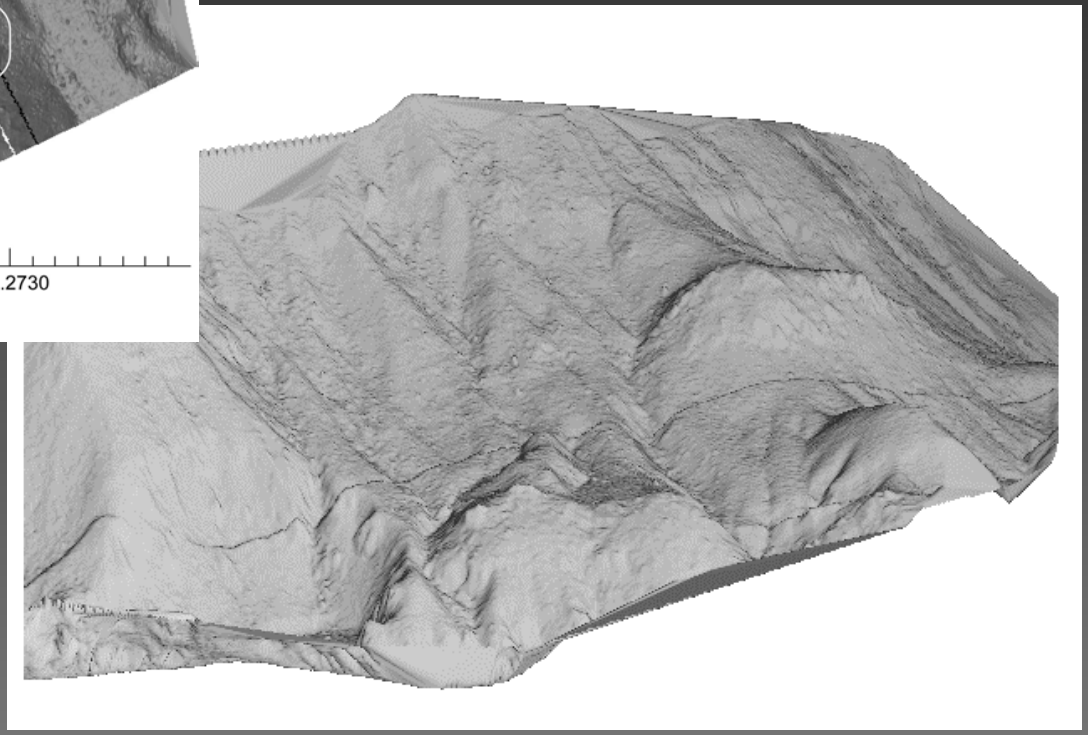
Airborne platform navigation must be highly precise and requires high-rate GPS data



- representation of actual fault ruptures recorded and preserved in unprecedented detail for use by future earthquake researchers

Estimating slip on ‘max. slip’ segment of the fault





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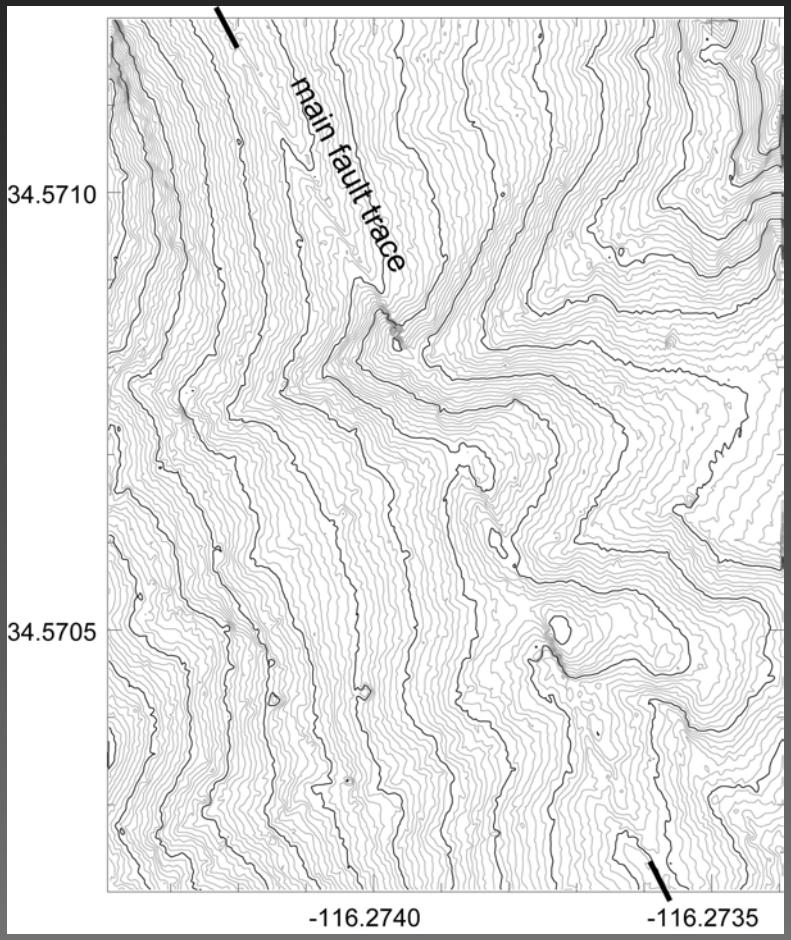
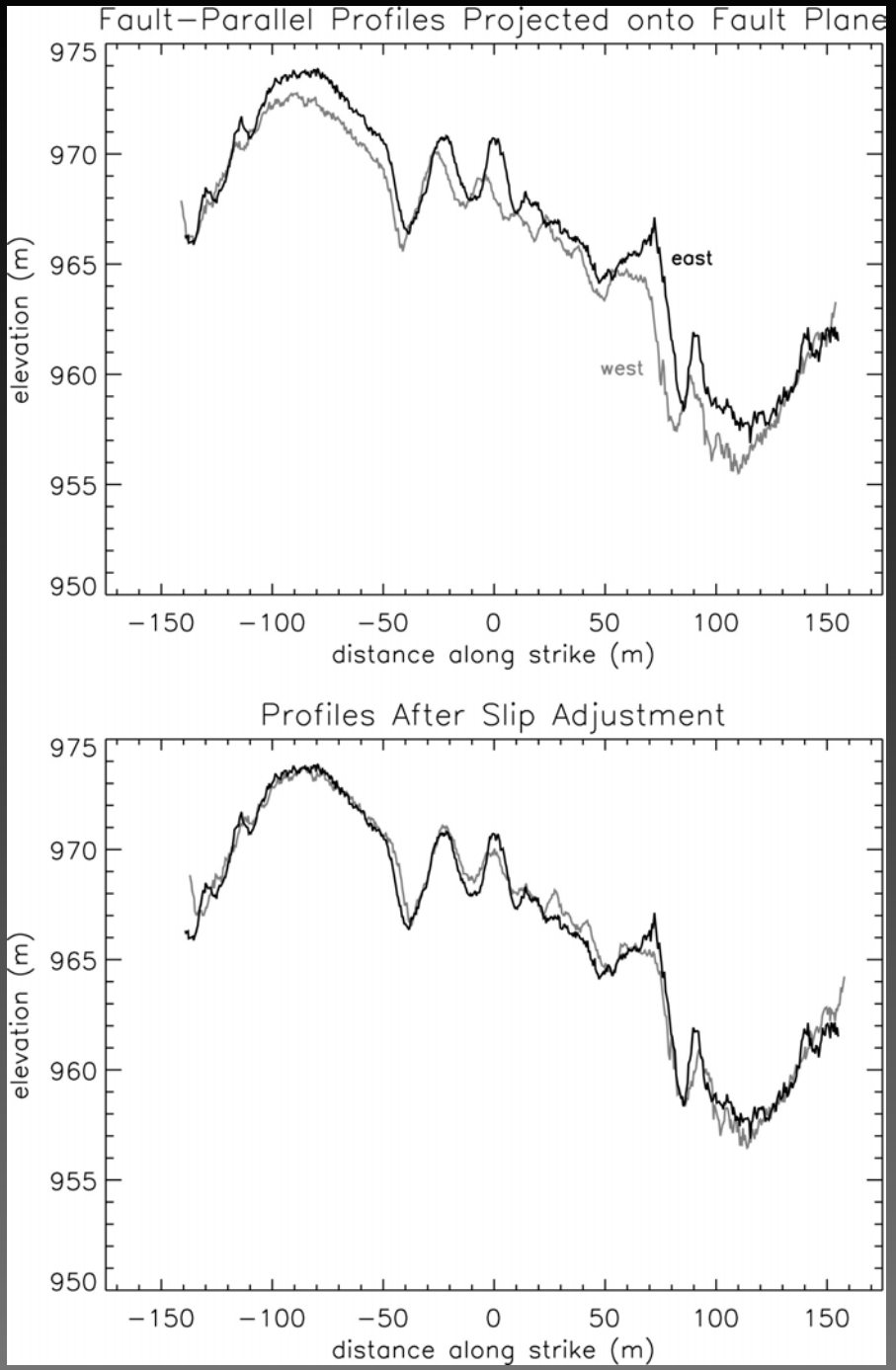
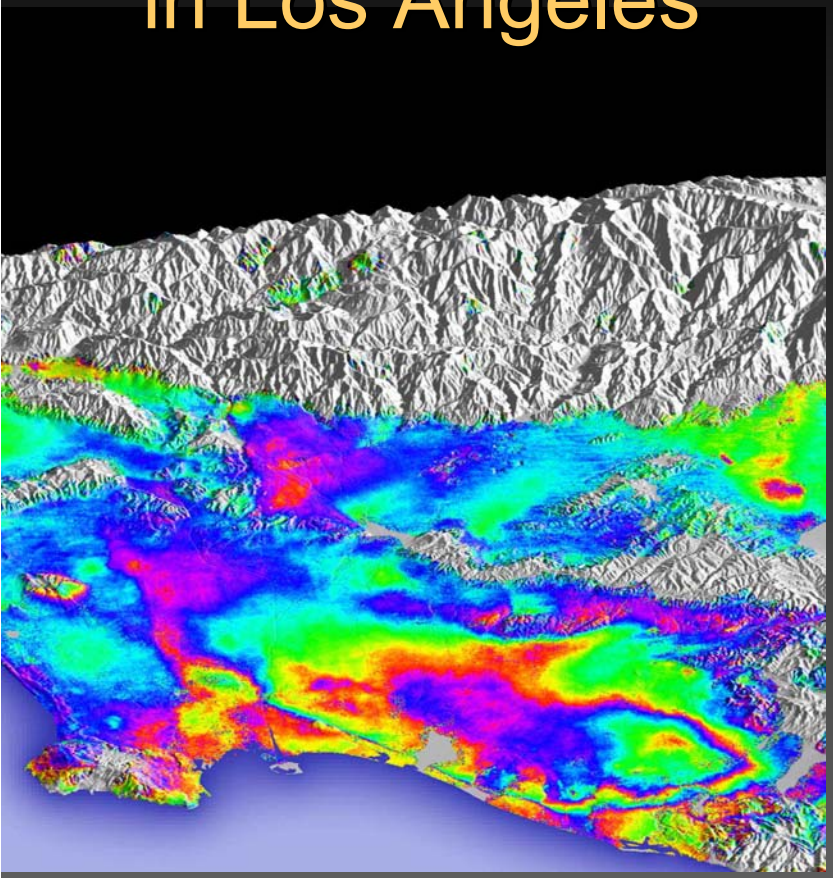




SCIGN and CSRC in Los Angeles



Courtesy of Gerald Bawden, USGS

- Natural and human-induced reasons for the partnership
- Mutual GPS data interests
  - SCIGN as CORS
  - High-rate (1 second)
  - Real-time
- Different needs
  - Scientific
  - Hazards
  - Emergency response
  - Mapping
  - Land Surveying
- Proven track record of cooperation
- Phased approach to converting SCIGN stations to real-time in LA

Microsoft Word - SCIGN GPS Station Visit and Troubleshooting Form version 1

File Edit View Insert Format Tools Table Window Help Acrobat

SOUTHERN CALIFORNIA INTEGRATED GPS NETWORK

TROUBLESHOOTING CHECKLIST AND REPORT

(VERSION A, FEB02)

1. 4-CHARACTER STATION CODE	2. STATION NAME OR LOCATION	3. VISIT DATE
4. NAME, AGENCY, PHONE AND FAX C		
5. NAME, AGENCY, PHONE AND FAX C		
6. POTENTIAL NATURE OF PROBLEM A		

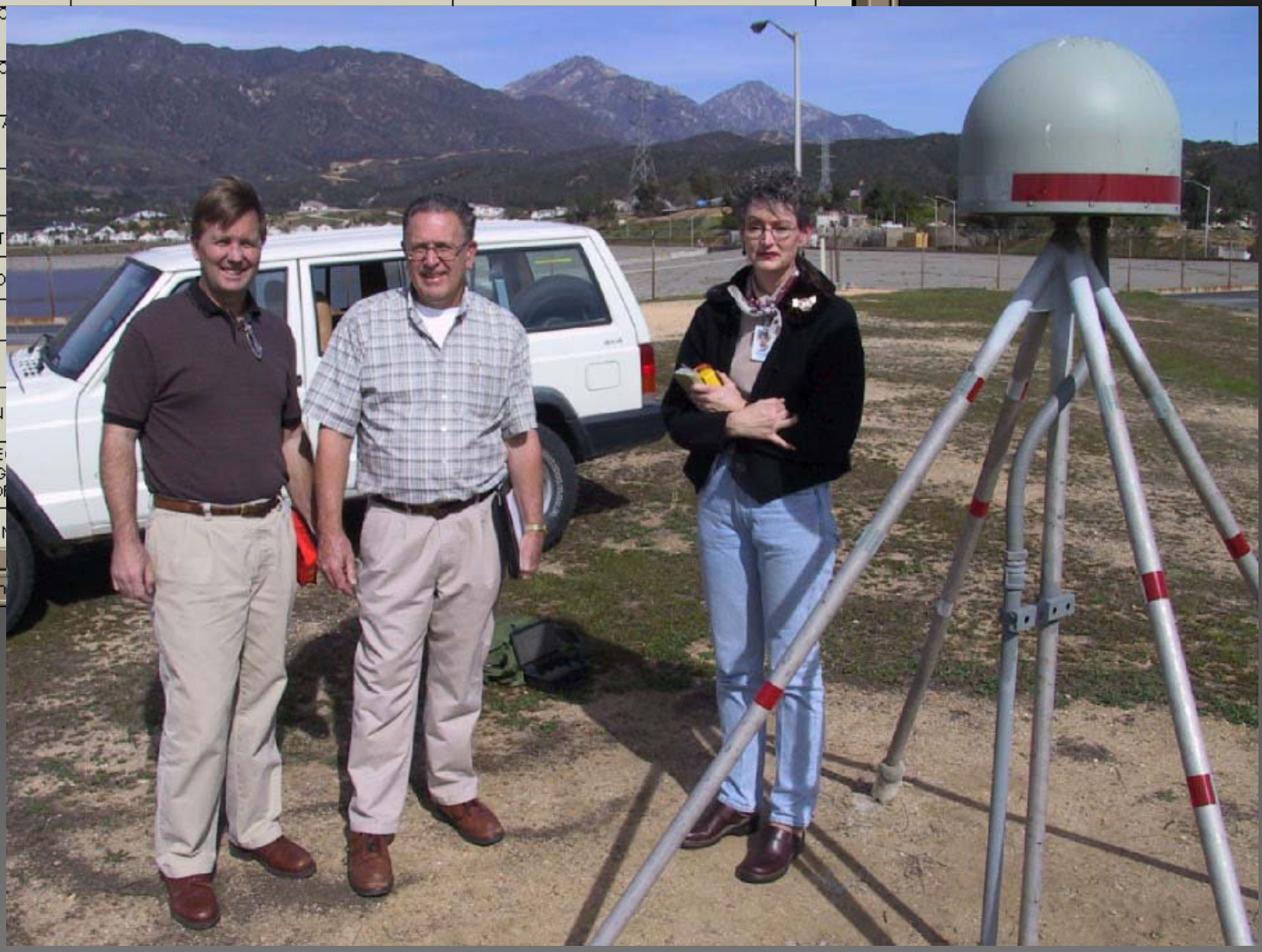
PRE-VISIT CHECKLIST

7. ☐	KEYS (GATES, ENCLOSURE, ET
10. ☐	LAPTOP PC w/ DOWNLOAD PRO
13. ☐	VOLTMETER

ON-STATION TASKS

16.	IS THE EXTERIOR OF THE STATION
17.	IS THE POWER SUPPLY (SOLAR RE BLINKING OR STEADY RED "CHARG ON THE APC SURGE ARRESTOR, O
18.	IS THE GPS RECEIVER ON? (PUSHIN

Page 1 Sec 1 1/1 At 3.9" Ln



Earthquake scientists do need high-rate GPS data in real-time

Can we afford it?
Can we afford not to have it?
How can our partners help us to make this work?

- Earthquake response
  - rapidly assess source
- Damage estimation
  - rapidly assess losses
- Infrastructure for positioning
  - support data and mapping

Conclusions

- State-of-the-art GPS networks and technology development have been funded by scientific agencies for earthquake research and response:
  - Static deformation field data; rapid tilt and strain mapping
  - Monitoring of large engineered structures (e.g., dams, buildings)
- SCIGN and CSRC together represent a test-bed for trying possible solutions for both the present and future of spatial referencing:
  - Real-time GPS sub-networks (OCRTN, RCRTN & LARTN)
    - Precise RTK positioning for surveying, AVL and GIS applications
  - InSAR, Airborne Laser Swath Mapping (ALSM) and digital photography
    - SCIGN provides ground control for airborne imaging and surveys
    - Mapping and imaging for rapid assessment of damage to buildings, lifeline infrastructure, etc. (The National Map; Homeland Security)
- Collaboration between Scientific, Surveying, GIS, Engineering and Transportation communities has mutual benefits:
  - Networks are needed for science experiments and for spatial referencing, but the long-term support of stations is difficult to ensure (unless other government agencies intend to sustain stations as essential infrastructure for other purposes)
  - CSRC funds are being highly leveraged with funds from scientific agencies, and are being used to support activities that had been funded by SCIGN in the past, and to replace aging but essential SCIGN hardware systems


Arthur C. Clarke's 2nd Law:
"The only way of discovering the limits of the possible
is to venture a little way past them into the impossible."
For additional information –
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http://pasadena.wr.usgs.gov/
http://www.scign.org/
http://www.trinet.org/
USGS photo
by John Galetzka